IMAGE FORMING APPARATUS

FIELD OF THE INVENTION AND RELATED ART

The present invention relates to an image forming apparatus, for example, a copying machine, a printer, a facsimile machine, in particular, an image forming apparatus which transfers a toner image on an image bearing member onto intermediary transfer medium, and transfers the image on intermediary transfer medium onto a piece of transfer medium.

There have been known various image formation systems for a color image forming apparatus, for example, a thermal transfer system, an ink jet system, and the like. Among these systems, an electrophotographic system is superior to the rest in terms of image formation speed, image quality, noise level, and the like aspects.

There are also various electrophotographic systems, for example, a multiple layer development system, a multiple layer transfer system, an intermediary transfer system, and the like. According to a multiple layer development system, a plurality of color images (plurality of toner images of different color) are formed in layers on the peripheral surface of a photosensitive member, and then, the plurality of toner images on the photosensitive member are transferred all at once onto a piece of transfer

medium. According to a multiple layer transfer system, a plurality of toner images of different color are consecutively transferred onto a piece of transfer medium as each of them is formed. In comparison, according to an intermediary transfer system, a plurality of toner images of different color are consecutively transferred (first transfer) onto an intermediary transfer medium as each of them is formed, and then, the plurality of toner images of different color are transferred all at once (secondary transfer) onto a piece of transfer medium. Among these electrophotographic systems, an intermediary transfer system enjoys substantial advantages: for example, there is little possibility of color mixing, and various transfer media different in quality, thickness, or the like properties, can be used.

Figure 9 is a schematic sectional view of an image forming apparatus (full color laser beam printer based on four primary colors) which uses one of the conventional intermediary transfer systems, and depicts the general structure of the image forming apparatus.

As depicted by the drawing, along the peripheral surface of the photosensitive drum 1, a charging apparatus 2, an exposing apparatus 3, a developing apparatus 5, an intermediary transfer belt 18, a photosensitive drum cleaner 16, and a discharge

roller 17, are disposed in the rotational direction of the photosensitive drum 1 (direction R1 indicated by an arrow mark), in the listed order. The photosensitive drum 1 is an image bearing member, and the exposing apparatus 3 projects a laser beam L onto the peripheral surface of the photosensitive drum 1.

Here, the image forming process of this image forming apparatus will be briefly described.

First, the photosensitive drum 1 is uniformly charged by the charging apparatus 2, and an electrostatic latent image is formed on the peripheral surface of the photosensitive drum 1 by the laser beam L from the exposing apparatus 3. Each electrostatic latent image is developed by one of the developing devices in the developing apparatus 5: yellow color developing device 5a, cyan color developing device 5b, magenta color developing device 5c, and black color developing device 5d, and transferred (first transfer) onto the intermediary transfer belt 18, in a primary transfer station N1. As a result, a color image constituted of four toner images of different color is created.

The color image on the intermediary transfer belt 18 is transferred (secondary transfer) all at once onto a transfer medium P as a transfer roller 7 for the secondary transfer is pressed upon the intermediary transfer belt 18, with the transfer

medium P being pinched between the roller 7 and belt 18. After the secondary transfer, the transfer medium P is conveyed to a fixing apparatus (unillustrated), in which the color image consisting of four toner images of different color is fixed to the surface of the transfer medium P by the application of heat and pressure. Thereafter, the transfer medium P is discharged from the image forming apparatus.

In the past, in order to prevent the problem that after a toner image is transferred onto the intermediary transfer belt 18, the toner particles are scattered from the toner image at the locations where the intermediary transfer belt 18 is bent (where rollers 8, 9, and 10 support intermediary transfer belt 18), the intermediary transfer belt 18 was provided with a surface layer with higher volumetric resistivity, located on the side onto which a toner image is transferred.

However, providing the intermediary transfer belt 18 with the surface layer with higher volumetric resistivity often triggered electrical discharge between the photosensitive drum 1 and the intermediary transfer belt 18 during the primary transfer, negatively affecting the image formation process. As a result, a toner image with traces of electrical discharge as illustrated by Figure 10 was produced; in other words, the so-called "image with shark skin

texture" was produced. The effects of this phenomenon were more conspicuous when a half tone image was produced.

SUMMARY OF THE INVENTION

The primary object of the present invention is to provide an image forming apparatus which can prevent the problem that the quality of a toner image is reduced after the toner image is transferred onto the intermediary transfer medium from the image bearing member.

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic sectional view of the image forming apparatus in the first embodiment of the present invention.

Figure 2 is a schematic sectional view of the intermediary transfer belt of the image forming apparatus in the first embodiment of the present invention.

Figure 3 is a schematic drawing which depicts

the process through which an image with "shark skin-like" texture is produced.

Figure 4 is a schematic drawing which shows the electrical charge distribution on an intermediary transfer belt with no electrical charge releasing layer.

Figure 5 is a schematic drawing which shows the electrical charge distribution on the intermediary transfer belt of the image forming apparatus, which is provided with an electrical charge releasing layer, (a) depicting a case in which the layer has a proper thickness, and (b) depicting a case in which the layer is thicker.

Figure 6 is a sectional view of the intermediary transfer belt of the image forming apparatus in the second embodiment of the present invention.

Figure 7 is a schematic sectional view of the image forming apparatus in the third embodiment of the present invention.

Figure 8 is a schematic sectional view of the intermediary transfer drum of the image forming apparatus in the third embodiment of the present invention.

Figure 9 is a schematic sectional view of a conventional image forming apparatus.

Figure 10 is a schematic drawing which

depicts the so-called "shark skin texture" having developed in an image on the intermediary transfer belt.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiment 1

Figure 1 is a schematic sectional view of the image forming apparatus in the first embodiment of the present invention, which is capable of forming color images. In the drawing, the same components as those in Figure 9 are given the same referential characters.

A photosensitive drum 1 as an image bearing means (image bearing member) comprises a cylindrical base member formed of aluminum or the like material, and a photosensitive layer formed by coating photoconductive substance on the peripheral surface of the base member. As for photoconductive substances, OPC (organic photoconductor), A-Si (amorphous silicon), CdS (Cadmium Sulfate), Se (selenium), and the like can be used. The photosensitive drum 1 is rotatively driven by a driving means (unillustrated) at a predetermined process speed in the direction indicated by an arrow mark R1.

A charging apparatus 2 is a scorotron type charging device, which charges the peripheral surface of the photosensitive drum 1, with corona ions generated through corona discharge.

An exposing apparatus 3 exposes the peripheral surface of the photosensitive drum 1 charged with the charging apparatus 2, to the exposing light L modulated with the inputted image data. It comprises a laser driver, a laser diode, and a polygon mirror, which are not illustrated, a deflective mirror 4, and the like. More specifically, the laser beam is outputted from the laser diode in response to the inputted image data, deflected by the polygon mirror, deflective mirror, and the like, and exposes the peripheral surface of the photosensitive drum 1. As a result, an electrostatic latent image, which reflects the inputted image data, is formed.

A developing apparatus 5 develops the electrostatic latent image on the photosensitive drum 1. It comprises a yellow color developing device 5a, a cyan color developing device 5b, a magenta color developing device 5c, and a black color developing device 5d, which are mounted in a rotatively supported rotary 5A. The yellow color developing device 5a, cyan color developing device 5b, magenta color developing device 5c, and black color developing device 5d are moved by the rotation of the rotary 5A to the developing position, so that a specific developing device correspondent to the color to which the latent image on the peripheral surface of the photosensitive drum 1 is to be developed squarely

faces the peripheral surface of the photosensitive drum 1. In the development station, toner is adhered to the latent image; the latent im ge is developed (visualized).

An intermediary transfer belt 6 as an intermediary transfer medium is stretched around a supporting means constituted of a driving roller 8, a counter roller 9 for the secondary transfer, and a tension roller 10, with the application of a tension of 4 - 8 kg, and is moved in the direction indicated by an arrow mark R9. In the primary transfer station N1 in which the intermediary transfer belt comes in contact with the photosensitive drum 1, a primary transfer roller 11 is disposed so that the intermediary transfer belt 6 is pinched between the primary transfer roller 11 and the photosensitive drum 1. The primary transfer roller 11 is connected to a high voltage power source 12. There is disposed a transfer roller 7 for the secondary transfer, opposing the counter roller 9 for secondary transfer, with the intermediary transfer belt 6 being positioned between the counter roller 9 and the transfer roller 7 for the secondary transfer. The point where the transfer roller 7 for the secondary transfer, counter roller 9, and intermediary transfer belt 6 meet constitutes the secondary transfer station N2. In order to carry out the secondary transfer, the transfer roller 7 for the

secondary transfer is pressed upon th intermediary transfer belt 6 with a predetermined timing, with a transfer medium P being pinched between the transfer roller 7 for the secondary transfer and the intermediary transfer belt 6. After the secondary transfer, the transfer belt 7 for the secondary transfer is moved away from the intermediary transfer belt 6 in the direction indicated by an arrow mark R6. The transfer roller 7 for the secondary transfer is connected to a high voltage power source 13.

Along the outward facing surface of the intermediary transfer belt 6, a cleaning apparatus 14 and an electric charge discharging device 15 are disposed between the counter roller 9 for the secondary transfer and the tension roller 10. The cleaning apparatus 14 removes from the intermediary transfer belt 6 the toner which remains on the intermediary transfer belt 6 after the secondary transfer, and the discharging device 15 removes the electrical charge from the intermediary transfer belt 6.

Next, the image forming operation of the image forming apparatus configured as described above will be described.

First, the photosensitive drum 1 is uniformly charged by the charging apparatus 2, and an electrostatic latent image is formed on the peripheral

surface of the photosensitive drum 1 by the exposing light L. or the laser beam from the exposing apparatus 3. The electrostatic latent image on the photosensitive drum 1 is developed by the pertinent developing device among the yellow color developing device 5a, cyan color developing device 5b, magenta color developing device 5c, and black color developing device 5d, and is transferred (primary transfer) onto the intermediary transfer belt 6 which is moved in contact with the photosensitive drum 1. This process is consecutively repeated for each primary color. As a result, four monochrome color images of different color are placed in layers on the intermediary transfer belt 6, creating a so-called color image.

Then, the transfer roller 7 for the secondary transfer is pressed upon the intermediary transfer belt 6, with the transfer medium P being pinched between the transfer roller 7 for the secondary transfer and the intermediary transfer belt 6. As a result, the color image is transferred all at once onto the transfer medium 9. After the secondary transfer, the transfer medium 9 is conveyed to a fixing apparatus (unillustrated), in which the color image is fixed to the surface of the transfer medium P by the application of heat and pressure. Thereafter, the transfer medium P is discharged from the apparatus.

Next, the above described primary and secondary transfer processes will be described in further detail.

(Primary Transfer Process)

When the photosensitive drum 1 is an OPC type photosensitive member, toner which is normally chargeable to positive polarity is used to develop an electrostatic latent image. Therefore, the polarity of the transfer bias applied to the primary transfer roller 11 by a high voltage power source 12 is positive.

The intermediary transfer belt 6 is desired to be formed of film of PVdf, nylon, PET, polycarbonate, or the like, which has a thickness of 10 - 200 μm and a volumetric resistivity of 10^{11} - 10^{16} Ω·cm (resistivity has been adjusted as necessary). The primary transfer roller 11 is desired to be a roller with a volumetric resistivity of no more than 10^5 Ω·cm. With the use of the intermediary transfer belt 6 formed of such thin film as described above, it is possible to generate several hundred to several thousand picofarads of static electricity in the primary transfer station N1 to flow stable transfer current.

(Second Transfer Process)

In the second transfer station N2, the counter roller 9 for the second transfer, which serves

as the counter electrode, is grounded, and a transfer bias with the positive polarity is being applied to the second transfer roller 7 by a high voltage power source 13. In this state, the transfer medium P is passed through the second transfer station N2 to carry out the second transfer.

After the second transfer process, the post-second transfer residual toner, or the toner remaining on peripheral surface of intermediary transfer belt 6 after the second transfer, is removed by the cleaning apparatus 4. Then, the intermediary transfer belt 6 is cleared of electrical charge by the discharging device 15. Generally, in order to improve the discharging efficiency of the discharging device 15, an electrode is disposed in contact with the intermediary transfer belt 6, on the side opposite to the discharging device 15. Meanwhile, the post-primary transfer residual toner, or the toner remaining on the photosensitive drum 1 after the primary transfer, is recovered by a photosensitive drum cleaner 16 so that the photosensitive drum 1 can be initialized for the following image forming operation, by a charge removing roller 17.

Further, in order to prolong the service life of the intermediary transfer belt 6, as well as to prevent the toner particles of the toner image from being scattered, the elastic layer, as the base layer,

of the intermediary transfer belt 6 may be provided with a surface layer formed of fluorinated resin or the like with a high volumetric resistivity.

Referring to Figure 2, the intermediary transfer belt 6 in this embodiment comprises a rubber layer 6a as the elastic layer, a high electrical resistance layer 6b, and a 3 μm thick charge releasing layer 6c, which are layered in this order from the bottom. The volumetric resistivity of the charge releasing layer 6c is smaller than that of the high resistance layer 6b.

The research conducted by the inventors of the present invention in regard to the formation of a low quality image negatively affected by the shark skin-like texture effected by electrical discharge revealed the following.

(1) The shark skin-like texture is liable to be effected in an environment with low humidity.

(2) The shark skin-like texture is liable to be effected approximately in proportion to the voltage level of the primary transfer bias. The shark skin-like texture is more liable to occur when a toner image of the fourth color is transferred (primary transfer), because the intermediary transfer belt 6 is charged up each time the primary transfer process is carried out, making it necessary to increase the primary transfer voltage for the following color toner

image.

(3) The shark skin-like texture is less likely to occur approximately in reverse proportion to the surface resistance of the intermediary transfer belt.

Based on the above discoveries, it is conceivable that the cause of the sharp skin-like texture is traceable to the abnormal electrical discharge which occurs adjacent to the primary transfer station N1 between the photosensitive drum 1 and the primary transfer roller 11, more specifically, through the microscopic gaps G1 and G2 between the intermediary transfer belt 6 and the photosensitive drum 1 illustrated in Figure 3.

Figure 4 is a schematic drawing which depicts the electrical charge distribution across the peripheral surface of an intermediary transfer belt 6A, in the microscopic gaps G1 and G2 between the intermediary transfer belt 6A and the photosensitive drum 1. The intermediary transfer belt 6A is not provided with the charge releasing layer 6c which is provided on the high resistance layer 6b of the intermediary transfer belt 6. In this case, if the strength of the electrical field between the surface of the intermediary transfer belt 6A and the peripheral surface of the photosensitive drum 1 is excessive, the electrical discharge occurs through the gaps.

On the other hand, if the charge releasing layer 6c is provided on the high resistance layer 6b as in the case of the intermediary transfer belt 6 in this embodiment illustrated by Figure 5, (a), the electrical charge on the intermediary transfer belt 6 horizontally transfers by a proper amount through the charge releasing layer 6c (in the direction in which intermediary transfer belt 6 is moved). Therefore, the electrical field between the intermediary transfer belt 6 and the photosensitive drum 1, in the microscopic gaps G1 and G2, is reduced in strength. Consequently, the electrical discharge does not occur through the gaps.

Referring to Figure 5, (b), if the charge releasing layer 6c is given an excessive amount of charge releasing capacity (charge releasing layer 6b is thickened), the electrical charge which is to transfer from the peripheral surface of the photosensitive drum 1 to the intermediary transfer belt 6 during the primary transfer is almost completely lost; in particular, the charge across the portions of the peripheral surface of photosensitive drum 1 correspondent to the colorless portions (portions not covered with toner) of the color image is almost completely lost. Therefore, the wall of the electric charge which laterally supports the toner image on the intermediary transfer belt 6 is lost; in

other words, the force which keeps the toner adhered to the intermediary transf r belt 6 is lost, making it easier for the toner particles of the toner image to be scattered at the points where the intermediary transfer belt 6 is bent.

In a test in which the charge releasing layer was made to be 20 µm, the toner particles were scattered from the toner image during the primary transfer. Therefore, an additional research was done by the inventors of the present invention while paying attention to the relationship between the charge releasing layer 6c and the quality of the image (toner image to be transferred onto intermediary transfer belt 6), obtaining the following results given in Table 1.

Table 1

Thickness of discharging layer	None	1µm	3µm	5µm	10µm	20µm
Image	N/G	G/G	G/G	G/G	G/N	G/N

Shark-skin like texture/scattering

G: Did not occur

N: Occurred

As is evident from Table 1, when the thickness of the charge releasing layer 6c exceeded 5

µm, the toner particles were scattered from the toner image. This was thought to be because, as the thickness of the charge releasing layer 6c was thickened, the effects of the high resistance layer 6b upon the surface of the intermediary transfer belt 6 failed to manifest; in other words, the intermediary transfer belt 6 failed to hold the charge on its surface, allowing the toner particles to scatter from the toner image.

As described above, in this embodiment, a charge releasing layer 6c which had a thickness of 1 - 5 µm and was lower in volumetric resistivity than the high resistance layer 6b, was provided on the high resistance layer 6b, so that the toner particles did not scatter from the toner image. Therefore, the shark skin-like texture did not occur.

The rubber layer 6a of the intermediary transfer belt 6 in this embodiment comprised a mesh of polyester fiber and epichlorohydrin rubber. More specifically, the mesh had a pitch of 0.5 mm, and the polyester fiber had a weight of 75 denier. The epichlorohydrin rubber had been adjusted in volumetric resistivity to 10^6 Ω·m, and was applied to both the top and bottom sides of the mesh. The overall thickness of the intermediary transfer belt 6 was 0.7 mm. Instead of the epichlorohydrin rubber, NBR (nitryl butadiene rubber), CR (chloroprene rubber), or

the like may be employed as the material for the rubber layer.

The high resistance layer 6b was formed of a mixture between a material belonging to a urethane group, and a fluorinated material, the volumetric resistivity of which had been adjusted to 10^{14} Ω·cm. In manufacturing the intermediary transfer belt 6, the mixture was dissolved in an organic solvent such as ethanol, and the solution was sprayed on the surface of the rubber layer 6a. The thickness of the high resistance layer 6b was made to be approximately 30 μm by controlling the number of times the rubber layer 6b was coated with the solution.

Similarly, the charge releasing layer 6c was formed of a mixture between a material belonging to urethane group, and a fluorinated material. The volumetric resistivity of the mixture as the material for the charge releasing layer 6b was adjusted to approximately 10^{13} Ω·cm by using a urethane group material having a smaller volumetric resistivity than the urethane group material for the high resistance layer 6b, as the material for the charge releasing layer 6c.

The fluorinated material was mixed into the urethane group material for the charge releasing layer 6c, or the outermost layer of the intermediary transfer belt 6, to improve the intermediary transfer

belt 6 in terms of toner release, so that the po t-second transfer residual toner could b easily removed.

This mixture was dissolved in an organic solvent, and the solvent was sprayed on the high resistance layer 6b. The thickness of the charge releasing layer 6c was made to be approximately 3 µm by adjusting the number of times the solution was coated.

The values of the volumetric resistivities of the aforementioned high resistance layer 6b and charge releasing layer 6c of the intermediary transfer belt 6 were the values obtained through the following measurement.

<Measuring Devices>

Resistance Meter: Super High Resistance Meter R8340A (Advantest Co.)

Sample Chamber: Super High Resistance Measurement Test Material Chamber TR42 (Advantest Co.; primary electrode diameter: 50 mm; guard ring internal diameter: 70 mm; and guard ring external diameter: 80 mm)

<Sample>

The materials for the charge releasing layer and the high resistance layer were coated on a sheet of aluminum to a thickness of 15 - 40 µm, and the coated aluminum sheet was cut into square pieces with

an edge length of 10 cm to use as measurement sample.

<Measurement Condition>

Temperature: 22 - 23°C

Humidity: 50 - 60 %

The measurement samples were left in the ambiance with a temperature of 22 - 23°C and a humidity of 50 - 60 % for no less than 24 hours.

Applied Voltage: 100 V

When impossible to measure due to the limiter (300 mA), a voltage of 1 V was applied.

Measurement Mode: program mode 5 (discharge: 10 seconds; charge: 30 seconds; and measurement: 30 seconds)

The research by the inventors of the present invention revealed that the volumetric resistivity of the high resistance layer 6b of the intermediary transfer belt 6 is desired to be in a range of 10^{11} - 10^{15} Ω·cm.

If the volumetric resistivity is no more than 10^{11} Ω·cm, the aforementioned scattering of the toner occurred regardless of the thickness and volumetric resistivity of the charge releasing layer 6b. If the volumetric resistivity is no less than 10^{15} Ω·cm, the aforementioned shark skin-like texture occurred regardless of the thickness and volumetric resistivity of the charge releasing layer 6b.

Also, it became evident that the volumetric

resistivity of the charge releasing layer 6c is desir d to be in a range of 10^{10} - 10^{14} Ω·cm.

If the volumetric resistivity is no more than 10^{10} Ω·cm, the aforementioned scattering of the toner occurred regardless of the thickness of the charge releasing layer 6c, and if the volumetric resistivity is no less than 10^{14} Ω·cm, the aforementioned shark skin-like texture occurred regardless of the thickness of the charge releasing layer 6c.

In some tests, fluorine particles, silica particles, or the like were dispersed in the high resistance layer 6b and charge releasing layer 6c of the intermediary transfer belt 6 to adjust the coarseness and friction factor of the surface of the intermediary transfer belt 6. Also in these tests, the volumetric resistitivies were measured with the use of the above described method. The results were that when the volumetric resistivity of the charge releasing layer 6c was smaller than that of the high resistance layer 6b, the occurrence of the shark skin-like texture could be prevented.

Embodiment 2

Figure 6 is a schematic section of the intermediary transfer belt 6 employed in the image forming apparatus in this embodiment. Since the configuration of this image forming apparatus is the same as that of the image forming apparatus

illustrated in Figure 1, except for the structure of the intermediary transfer belt 6, the description of the structure and image forming operation of this image forming apparatus will be omitted here.

Referring to Figure 6, the intermediary transfer belt 6 employed in the image forming apparatus in this embodiment comprised a rubber layer 6a, a high resistance layer 6b laid on the surface of the rubber layer 6b, and a 4 μm thick charge releasing layer 6c laid on the surface of the high resistance layer 6b.

In this embodiment, the charge releasing layer 6c was composed of binder, which was the same material as that for the high resistance layer 6b, and particles dispersed in the binder. The volumetric resistivity of the particles was smaller than that of the material of the high resistance layer 6b.

Also in the case of this embodiment, in which the compound material composed of the material for the high resistance layer 6b and the particles with low electrical resistance was used as the material for the charge releasing layer 6c, it was possible to prevent the problem that abnormal electrical discharge occurs adjacent to the primary transfer station N1.

Further, also in this embodiment, research was conducted regarding the relationship between the charge releasing layer 6c and the quality of the image

(toner image to be transferred (primary transfer) as in the first embodiment. Th results are given in Table 2.

Table 2

Thickness of discharging layer	None	1μm	3μm	5μm	10μm
Image	N/G	G/G	G/G	G/G	G/N

Shark-skin like texture/scattering

G: Did not occur

N: Occurred

As is evident from Table 2, even when substance with low electrical resistance was dispersed in the material for the charge releasing layer 6c, the scattering of the toner particles occurred when the thickness of the charge releasing layer 6c exceeded 5 μm.

This is thought to occur because, as the thickness of the charge releasing layer 6c increases, the effects of the high resistance layer 6b (capacity of high resistance layer 6b in terms of holding toner image and electrical charge to intermediary transfer belt 6) reduces, making it difficult for the surface of the intermediary transfer belt 6 to retain the electrical charge which forms a wall of electrical

charge which holds th toner image. As a result, the toner particles are scattered from the toner image.

As described above, in this embodiment, the volumetric resistivity of the charge releasing layer 6c was made smaller than that of the high resistance layer 6b, and a 1 - 5 μm thick charge releasing layer 6c was provided on the high resistance layer 6b. As a result, the scattering of the toner particles from the toner image was prevented; an image suffering from the shark skin-like textured was not produced.

The rubber layer 6a of the intermediary transfer belt 6 in this embodiment was formed of the same material as that in the first embodiment. Also, the high resistance layer 6b was formed of the same material as that in the first embodiment, which was spray coated on the surface of the rubber layer 6a to a thickness of approximately 30 μm.

As for the material for the charge releasing layer 6c, the same material as that for the high resistance layer 6b was used as binder, and particles of PVdF (polyvinylidene fluoride) with a volumetric resistivity of 10^{13} Ω·cm were dispersed in the binder by 40 % by weight. The thus composed material was dissolved in an organic solvent such as ethanol, and the solvent was spray coated on the surface of the high resistance layer 6b while controlling the number of times the solution was coated so that the thickness

of the charge releasing layer 6c b came approximately 4 µm.

Embodiment 3

Figure 7 is a schematic sectional view of the image forming apparatus in this embodiment. In the drawings, the same members as those in the image forming apparatus illustrated in Figure 1 are given the same referential characters as those in Figure 1 so that duplication of the same description can be avoided.

The image forming apparatus in this embodiment is such an image forming apparatus that uses an intermediary transfer drum 20 as the intermediary transfer member. Except for the structure of the intermediary transfer member, the configuration of the image forming apparatus is the same as that of the apparatus in Figure 1, and therefore, its description will be omitted here.

As described above, the visual images developed on the photosensitive drum 1 from the electrostatic latent images on the photosensitive drum 1 by the yellow color developing device 5a, cyan color developing device 5b, magenta color developing device 5c, and black color developing device 5d are consecutively transferred (primary transfer) onto the intermediary transfer drum 20. More specifically, the intermediary transfer drum 20 is being rotated in the

direction indicated by an arrow mark R9, and as the primary transfer bias is applied to the metallic cylinder 20a, that is, the base member, of the intermediary transfer drum 20 by a high voltage power source 12, the monochrome images are consecutively layered onto the intermediary transfer drum 20, in the primary transfer station N1, as they are developed. After all the monochrome images are transferred onto the intermediary transfer drum 20, they are transferred all at once onto a transfer medium P in the secondary transfer station N2. After the secondary transfer, the post-secondary transfer residual toner on the intermediary transfer drum 20, that is, the toner remaining on the intermediary transfer drum 20 after the secondary transfer, is removed by a cleaning apparatus 14, and the surface charge of the intermediary transfer drum 20 is removed by a charge discharging device 15.

Referring to Figure 8, the intermediary transfer drum 20 comprises: the metallic cylinder 20a; an elastic layer 20b which is formed of rubber or the like material, and placed on the peripheral surface of the metallic cylinder 20a; a high electric resistance layer 20c placed on the surface of the elastic layer 20b; and a charge releasing layer 20d placed on the surface of the high resistance layer 20c. The volumetric resistivity of the charge releasing layer

20d is smaller than that of the high resistance layer 20c.

Even when the intermediary transfer drum 20 was used as the intermediary transfer member, the provision of the high resistance layer 20c was effective to prevent the toner particles from scattering from the toner image. However, abnormal electrical discharge occurred in the primary transfer station N1, resulting in an image suffering from the aforementioned shark skin-like texture.

On the other hand, when it was made easier for the electrical charge on the peripheral surface of the intermediary transfer drum 20 to move in the horizontal direction (rotational direction of intermediary transfer drum 20), by providing the charge releasing layer 20d on the high resistance layer 20c, the electrical charge on the peripheral surface of the intermediary transfer drum 20 was uniformly distributed, preventing the formation of images suffering from the shark skin-like texture.

Further, when research was done regarding the relationship between the charge releasing layer 20d and the quality of the image (toner image to be transferred onto intermediary transfer drum 20) as they were regarding those in the first and second embodiments, the results shown in Table 3 given below were obtained.

Table 3

Thickness of discharging layer	None	1μm	3μm	5μm	10μm	15μm
Image	N/G	G/G	G/G	G/G	G/N	G/N

Shark-skin like texture/scattering

G: Did not occur

N: Occurred

As is evident from Table 3, when the thickness of the charge releasing layer 20d of the intermediary transfer drum 20 exceeded 5 μm, the toner particles were scattered from the toner image.

It was also thought in the course of this research that, as the thickness of the charge releasing layer 20d was increased, the effects of the high resistance layer 20c upon the surface properties of the intermediary transfer drum 20 was reduced, making it difficult for the surface of the intermediary transfer drum 20 to retain the electrical charge, which resulted in the scattering of the toner particles from the toner image.

As described above, in this embodiment, the volumetric resistivity of the charge releasing layer 20d was made smaller than that of the high resistance layer 20c, and a charge releasing layer 20d with a

thickness of 1 - 5 µm was provid d on the surface of the high resistance layer 20c to prevent the scattering of the toner particles from the toner image. As a result, the formation of an image suffering from the shark skin-like texture could be prevented.

Also in this embodiment, an aluminum cylinder with a diameter of approximately 50 mm was employed as the metallic cylinder 20a for the intermediary transfer drum 20. As for the material for the elastic layer 20b, NBR, the volumetric resistivity of which had been adjusted to 10^6 Ω·cm by dispersing carbon in it, was used, and this material was coated on the peripheral surface of the metallic cylinder 20a. The thickness of the elastic layer 20a was adjusted to approximately 3.0 mm by polishing.

As for the materials for the high resistance layer 20c and charge releasing layer 20d, the same materials as those used in the first and second embodiments were used. They were spray coated while controlling the number of times the materials were coated so that the thicknesses of the high resistance layer 20c and charge releasing layer 20d became approximately 20 µm and 3 µm, respectively.

As for the material for the charge releasing layer 20d, a material in which particles with low electrical resistivity was used. Therefore, even when

the thickness of the charge releasing layer 20d was in a range of 1 - 5 µm, the scattering of the toner particles from the toner image did not occur, and also it was possible to prevent the formation of an image suffering from the shark skin-like texture.

While the invention has been described with reference to the above described first to third embodiments of the present invention, it is not confined to the details set forth, and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.

For example, the present invention is also applicable to such an image forming apparatus that comprises four photosensitive drums, that is, one photosensitive drum for each of four primary colors: yellow, magenta, cyan, and black, in which the toner image formed on each photosensitive drum is electrostatically and consecutively transferred (primary transfer) in layers onto an intermediary transfer belt (or drum); and the toner images on the intermediary transfer belt (or drum) are transferred all at once onto a transfer medium.